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EXPLORATIONS IN RESEARCH DESIGN--CURRICULUMS FOR TECHNICIANS.

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A MATRIX MODEL WAS CONSTRUCTED FOR DEMONSTRATING THE RELATIONSHIPS OF SPECIFIC CONCEPTS, SKILLS, AND/OR COURSES TO VARIOUS TECHNICAL OCCUPATIONS. DEVELOPMENT OF THE MODEL WAS ACCOMPLISHED IN THREE PHASES--(1) COLLECTION OF OCCUPATIONAL ANALYSES DATA AND RELATED PUBLICATIONS, (2) CRITICAL ANALYSES OF THE COLLECTED DATA AND CONFERENCE DISCUSSIONS CONCERNING THE RESULTS, AND (3) DETERNINATION OF A STRATEGIC RESEARCH DESIGN FOR STUDIES ACROSS THE ENTIRE FIELD OF OCCUPATIONS FOR TECHNICIANS. (JH)

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EXPLORATIONS IN RESEARCH DESIGN: CURRICULA FOR TECHNICIANS

The Report of an Investigation
Toward Development of a Research Design
For Discovering the Functional Understandings of
Technicians as Bases for Technical Curriculum Planning

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Michigan State University and the U. S. Office of Education
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G. L. B.

Michigan State University
East Lansing
November 1960

FOREWORD

The College of Education has happily joined hands with the Cooperative Research Program of the U. S. Office of Education in order to study an important phase of the American educational effort. The interest, suggestions, and financial support of the U.S. Office has been most valuable to us.

As our industrial revolution progresses, our society needs an ever-increasing number of trained technicians. The purpose of this project was to discover what content ought to be included in senior-high-school and junior-community-college programs. The research necessary to carry on long-term, continuous reorganization of such curricula was also part of this study.

It is obvious that we are in a period of great social and technical change. The education of technicians during periods of dramatic social change becomes an increasingly difficult problem. The increasing competition among employers for the most able part of our student population also adds to the complexities of program development.

We hope the findings of this project will add to an understanding of the skills, aptitudes, and educational requirements needed in technical fields. We also hope that it will be helpful in establishing the need for a continuous research base. Such research is required if curriculum construction and education programs are to be intelligently conceived and effectively administered.

Clifford E. Erickson
Dean, College of Education

CONTENTS

Foreword

I. The Technician Problem and the Focus of Project 629 1

A. General Aspects of the Problem Surrounding Technician Research 3

B. The Major Purposes of this Study 11

II. Contemporary Technician Research 13

III. The Research Procedure of Project 629 20

IV. Exploring the Role and Contribution of Occupational Analysis 26

A. General Results of the Conference 27

B. Consultant Suggestions and Recommendations 31

C. General Reaction of the Investigator to Discussion and Recommendations 35

V. Exploring Problems and Methods of Technician Research 37

A. Personnel and Nature of the Second Research Conference 37

B. General Nature of the Discussion 39

C. Educational Values in Change, Selection, and Nature of Work 41

D. Criteria and Evaluation -- Critical Areas to Identify Occupations 44

E. Suggestions for Pilot and Long-Term Technician Research 45

F. A Synthesis of the Two Research Conferences 51

VI. The Resolution of a Research Design 54

A. Outline -- Matrix Model 56

B. Discussion of the Outline 56

VII. Some Conclusions and an Overview 62

Appendix 67

Index to Project 629 Publications 68

Research Consultants, Project 629 69

Suggested Consultants 71

Abstract 73

P629 (8186) R7m

Developmental Technician Research

Final Report [1]

I. The Technician Problem and the Focus of Project 629

The myriad of problems surrounding the technician, his preparation, utilization, upgrading, classification, relationship to scientist and engineer, and many others constitute a complex of enormity. Perceptibly, he is the man of the hour. Descriptions and definitions about his work and understandings, more so his position on the hierarchy of job levels, are as varied and personal as one's choice of a filter cigarette or one's interpretation of the U-2 incident. Enormity of scope, near-universality of interest and active ideas, personal definitions with and without irritations -- these are the characterizations and concepts about the technician. These make up the climate of technician research.

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[1] The research reported herein was performed pursuant to a contract with the Cooperative Research Section of the United States Office of Education, Department of Health, Education, and Welfare, Project 629.

Two general research problems, delimitation and sampling, are especially critical in research about technicians. Both made themselves felt throughout this study. The investigator became increasingly sensitive to delimitation as he considered the role of education in developing the technician as a well-rounded, integrated person. The problem of sampling was made more complex by the factors of geography, lack of occupational definition, the size of the organization in which a technician may work, and the industrial classification of the establishment which employs him.

Generally, at least to educators, the postulate seems quite acceptable that technicians can be prepared, and that public education should help prepare them. This fact is the thesis of Project 629. As the primary belief becomes related to <u>place</u> and <u>level</u> of education, school organization, place and importance of various subject matter, the extension of educational opportunity, and other traditional educational factors, the postulate assumes dimensions which are staggering.

Possibly akin in acceptance to the first postulate <u>might</u> be the acceptance of another: technicians should be taught applied knowledge. Project 629 has a continuing interest here. It chose to state its interest more forcibly as <u>functional understandings</u>, a basic criterion of all education.

A. General Aspects of the Problem Surrounding Technician Research

There are numerous aspects of the general conditions and hazards of engaging in research about technicians. No doubt, some of these are not peculiar to fact-finding about technicians. They confront every curious researcher who would progress impartially from the unknown to the informed. In terms of this research project, the following problems are critically related to the more specific hypothesis and purposes which are discussed later:

a. The basic freedom to perform research
b. The need for educated individuals
c. Our complex technology and the tempo of change
d. The concept of curriculum
e. The need for more and better research
f. The financial support of public education

Although Project 629 has been fortunate in the degree and amount of cooperation and frankness from each of its many consultants, it remains to be determined if preconceptions, irritations, and vested interests will ultimately minimize technician-research efforts. It is a paradox to witness the sustained interest of so many persons in discussing and discovering the nature of technician work and, at the same time, observe the fear of any research which may clarify the classification problem which seems to be the predominant interest. One is generally left with the impression that there are some questions (of a research

nature) which cannot be investigated. And thus we have research with reservations, or, to the more venturesome, research whose data and conclusions may be preconceived. Specification of the truth before knowing the facts seems not be characteristic of any one group of persons, profession, occupation, or interest. It will be tragic in its implications to education and vocational education in general, and to technical education in particular, if bias ultimately stands in the way of freedom of access to research information and to the dissemination of the information after it is discovered. With all the frustrations which seem to be induced by our complex of change and technology, it is one thing to try to reconcile or accelerate our educational lag; it is quite another endeavor to attempt research with limitations on freedom and frankness.

The need for educated individuals, however variously conceived, requires no documentation. Project 629 would make, however, a distinct case for educated technicians. This is not to say that it is less important to have educated craftsmen or persons in other occupations. Somehow we seem to have come to believe, or at least leave the impression, that education of a vocational nature cannot be other than "training". In some circles the words "education" and "training" are used synonymously, and even here the users do recognize the vast and important

distinction. Though there seems to be no disagreement over the need for educated men, there is strong controversy about the way in which they should be educated. Discussion of technicians and their preparation invariably stimulates concern for the educated (not the trained) person. The implication left to the listener is that the technician will have to use intelligence, be a maker of decisions, be adaptable to rapid change, make many applications of scientific and mathematical knowledge, and, on a continuing basis, be educable. As one technician interviewee earnestly repeats to us in admonishment, "You must teach him (the technician) good judgment, common sense, and intelligence." He has faith that education can and should teach intelligence as it does algebra, report writing, and magnetism.

Sputnik has become almost symbolic of the pace of our change, particularly of the change evident in modern technology. Technicians are at the heart of the process. In the span of fifteen years at mid-century, we have witnessed the amazing stride of science and technology from atom bombs to astronauts. Predictions of future refinements of these basic discoveries, not to mention new breakthroughs in basic science, are indicative that change and the adjustment to it will be our continuing problem. If we assume that education has traditionally lagged under the old order of the times and the present, what are the

proportions of the new challenge which we face?

The wise utilization of technical and scientific manpower has recognized the need of "job enlargement" rather than increased specialism in workers. As we see the gradual disappearance of repetitive operations under the influence of automation, and the increased premium upon knowing and application, we should become increasingly sensitive to the new demands made of workers and the education of them as adolescents and adults, in school and on the job. If we are in a mind to further disturb our educational complacency about change and technology, we might build a more dynamic concern for job displacement and worker mobility. A specification for education amid change is well stated by Peter Drucker:

> But the need is above all qualitative -- for better educated people. The "trained barbarian", the man who has acquired higher gadgeteering skill, will not do. Even in routine jobs, automation will require ability to think, a trained imagination, and good judgment, plus some skill in logical methods, some mathematical understanding, and some ability well above the elementary level to read and write -- in a word, the normal equipment of educated people. Under automation, a school could do a student no greater disservice than to prepare him as so many do today for his first job. If there is one thing certain under automation it is that the job -- even the bottom job -- will change radically and often. [2]

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[2] Peter F. Drucker, "The Promise of Automation: America's Next Twenty Years, Part II", Harper's Magazine, April 1955, p. 45.

Drucker's requirements of education for educated people are strongly related to teaching and curriculum. Right off, it is safe to wager that curriculum for technicians will suffer from the traditional lapses of most program planning. Concepts of curriculum for technicians will range from the very traditional to the progressive, from the pure science, ground-to-be covered program to the applied science and laboratory-centered and cooperative work experience.

Already there seems to be a confirmed assumption that all programs should be two years in length. Proponents who support the trend to postpone vocational education advocate that the junior-community college is the right place for technical education. Notwithstanding, graduates of technical high schools seem to be in greater demand than ever before. The basic nature and scope of the curriculum, its generalism and specialism are not clear. On top of all this, technical curriculums suffer the misunderstanding which arises from a stigma attached to the word "terminal". It was the hope of Project 629 that it might eventually help clarify the problem of curriculum for technicians without specifically detailing programs and courses in the process.

Change and all of its manifestations in our technology and the manpower needed for it have stimulated interest in research of many kinds. No doubt, our research efforts will have to be

increased manyfold if we expect to be knowledgeable about even engineering and scientific manpower. Obviously, we should be equally concerned with the research activity related to all occupations and professions now and for as far into the future as we dare make plans and predictions. As far as occupational research is concerned, it does not take an alarmist to realize that the urgency and dimensions of our problem have moved far from the place where the efforts of individual researchers will suffice. The problem now assumes proportions which make it necessary that we think in terms of research administration, recruiting interests and resources, enlisting adequate finances, and consolidating manifold assistance to make it possible to discover the knowledge we need.

Present research efforts about the technician seem to be concentrated in the survey, and much of this is primarily of the quantitative type, that is, as to how many technicians there are at the present time and how many will be needed in the next decade. The importance of this information should not be depreciated, but the education of technicians will have to stand on concepts which are vastly different in nature. Our snail's pace of research, both in amount and kind, hardly tells us clearly of the present nature of technician work and the knowledge needed; at the same time intelligent manpower

planning and education should be fortified with information which indicates the ways in which technicians should be utilized and should be prepared.

Some technician research has been initiated and supported by recent legislation. Title VIII of the National Defense Education Act is particularly concerned with the preparation of skilled technicians in area vocational programs and makes it clear that curriculums should be based upon occupational analyses of technicians' jobs.

The stimulation of the Act to research is highly important, but other basic provisions of Title VIII have more far-reaching implications: (1) educational opportunity is extended to more youth and adults through the establishment of area programs; (2) the importance of the technician and his distinct place on the engineering team is greatly enhanced and recognized; (3) the national need for technicians, rather than the local placement of them, is reflected and made a strong criterion; (4) the vitality given to expanded school-district reorganization, consolidation, and strategic location of programs is greatly needed; and (5) the defense of our country is dependent upon its strength of technical manpower and its education.

On the other hand some provisions of the Title demand clarification. Research is needed to more clearly define

"highly skilled technician", identify technical occupations necessary to the national defense, and specify mathematics and science needed by these workers.

Generally, description of the aforementioned problems composes Project 629. The most persistent problem is that of curriculum for the preparation of technicians. The education of technicians cannot move forward in the secondary school and community college until curriculum planners are made aware of the technician's work activities and responsibilities and their relationships to basic understandings in mathematics and science. It is also reasonable to assume that technicians have need for various communication methods (written, oral, graphic) and socio-economic skills. The work of the technician is unlike that of the craftsman, the former being primarily concerned with understanding and application, the latter being directly related to manipulative skill. Education should be able to teach the basic, fundamental understandings needed by beginning technicians as well as the advanced, specialized learnings required of technicians in service.

To bring into focus the immediate problem of Project 629, the research attempts to develop a research method to discover the basic uncerstandings which are critical to technical employment. The current conception of the technician, particularly

the technician in industry, derives from many kinds of research, from dubious samples, from the experiences of many individuals, with too much conjecture. Project 629 set out to collect some of the more reliable data, determine the ways in which they were assembled, and discover more scientific methods by which, in the opinions of specialists, they should be investigated. In a real sense, then, Project 629 seeks to study the ways in which a major study can best be made.

B. The Major Purposes of This Study

The primary purpose was to develop a research design or format which could be subsequently used to investigate the work functions and understandings of industrial technicians. If it could be determined that it is possible to design research and study of technicians, can instruments be developed to implement the research and collect the data? Although there was no intent to construct curriculums for technical education, it was hoped that procedures and processes might be discovered to prepare occupational data for the use of educational planners. Several secondary purposes were held for the nature of the data which may presently exist:

a. To what extent do present data describe the nature of highly skilled technician work, that is, in what

activities are technicians engaged and to what extent?

b. Do current data indicate the extent to which technicians use functional understandings in mathematics, science, communications, and human and supervisory relations?

c. Do the data reveal a common core or base in the educational programs of all industrial technicians?

d. What vocational guidance or occupational adjustment information may be discovered?

e. Might the data indicate the presence of clusters of technical occupations which might suggest a pattern or organization of educational programs?

It was hypothesized that if data (as they are characterized by the above purposes) can be obtained it is possible to shape a research design which may adequately sample the universe of the technician and accurately determine his functions and understandings. This hypothesis made necessary the investigation of occupational-analysis techniques and study of the classifications of industries in which technicians are employed; it was also recognized that study should be made of geographical sampling and the length of time necessary to conduct a major study.

II. Contemporary Technician Research

Research about technicians is not peculiar to the immediate time we live in. Various efforts of civil and military organizations and private industry have sought to define and clarify occupations, and education for them, for a long time. Obviously, purposes have been extremely varied and motivated by diverse problems. Such research is here reviewed, as it bears directly on the central purpose of Project 629.

There is little research on highly skilled technicians. Inquiries about comparable levels of technical employment are more appropriately about the engineering technician and the research - and - development technician. The very fact that we lack an acceptable definition of the term technician means that it is almost impossible to discuss the research effort as it occurs on many levels.

Federal agencies (and their state affiliates) probably expend more time, effort, and money than any other large group of investigators. Their purposes for the research are many and include education and its role in preparing technicians, engineers, scientists, other professionals, and a host of other workers. Divisions of the Department of Defense are actively

engaged in the research. In addition to conducting research, they contract investigations to universities and to private individuals and organizations. Research offices may be found at headquarters and bureau centers in Washington, D. C. and at strategic locations in the field. Investigations of the technician categories usually emanate from personnel-research divisions whose activity also includes research in the testing, evaluation, and selection of persons for technical billets.

In general consideration for the great amount of personnel research conducted by the various military departments, and by the Department of Defense, it is the opinion of this investigator that most educators interested in educational research for technical and scientific manpower might profit from a period of in-service experience with one of the various military offices. Their interest and cooperation are highly gratifying and very helpful. Particular instances of their cooperation and contributions to Project 629 are noticed later in this report.

No doubt many branches of the Department of Labor are active in the engineering and scienfitic manpower problem. Project 629 has worked solely with the Division of Placement Methods of the U.S. Employment Service. Inasmuch as the Occupational Analysis Branch completed 1) a pilot study of technicians who work directly with scientists and engineers,

and 2) a subsequent, more extensive study of research and development technicians, the data are directly within the interest of Project 629. Details of this research are most pertinent to the civilian economy and to public education. It suffices to say here that the data in the form of occupational analyses should be invaluable to curriculum makers, teachers, guidance personnel, students, and technicians themselves.

The Office of Education, U.S. Department of Health, Education, and Welfare has been charged with the administration of the National Defense Education Act. Title VIII of the Act is administered by the Area Vocational Education Branch of the Division of Vocational Education. Already several studies have appeared concerning curriculum suggestions for the preparation of technicians. These studies were made possible by an analysis of several of the occupations by the Department of Labor. In operation for only a short time, the Area Vocational Education Branch has not had a formal research program, inasmuch as it has concentrated on supplying critical information and materials to the various States to implement the provisions of Title VIII. The Assistant Commissioner of Vocational Education and the Director of the Area Vocational Education Branch and its personnel have contributed many ideas and clarified many questions connected with this research project.

The U.S. Civil Service Commission is attempting by testing and occupational analysis to clarify the technician problem. Investigators will find it profitable to review the job analyses and examinations of the Commission and to consult with the Commission's personnel, who are greatly interested in personnel research concerning technicians and their employment in the various activities of the Federal government.

The National Science Foundation is primarily interested in scientists and engineers and their education in mathematics and science. This fact should not be interpreted to mean that the Foundation has no interest in technicians. Project 629 consulted at length with the Program Director for Scientific Manpower. Education, particularly technical education, should realize that it has a strong resource here for the teaching of mathematics and science. On the other hand, researchers must not assume that the Foundation is interested in the education of technicians aside from mathematics and science.

Undoubtedly many other agencies on the national level of government are active to varying degrees in research activities concerned with technical manpower. If some consolidation could be made of their activities and the information they possess, it would be an invaluable service to educators. For the most part, Project 629 has worked with

those agencies which have been mentioned here. The project had no contact with the various committees which have been organized from time to time to deal with the critical aspects of our manpower complex.

Organizations affiliated with professional and industrial groups are interested in the technical manpower problem. For instance, the Instrument Society of America, with headquarters at Pittsburgh, has sponsored an extensive study of instrumentation technicians. The study is scheduled for completion in September 1960, and should be informative as to the role of the technician in instrumentation and his preparation. Another effort, that of the National Survey of Technical Institute Education conducted under the auspices of the Technical Institute Division of the American Society for Engineering Education, has resulted in a recent publication which should have an impact upon the education of technicians, especially engineering technicians.[3]

The impetus supplied by Title VIII of the National Defense Education Act and the interest of the various States to establish area vocational education programs have stimulated and produced considerable research at the state and community levels.

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[3] G. Ross Henninger, The Technical Institute in America, New York: McGraw-Hill Book Company, 1959.

Although most of this research has been survey-type, it is important insofar as it adds to knowledge about technicians. Several researchers have adapted or modified the unsophisticated approach to a qualitative survey of technician activities and understandings in Benton Harbor and St. Joseph, Michigan.[4] Many states have made surveys in cooperation with the various state employment services affiliated with the U.S. Employment Service. This investigator attempted to consolidate the survey effort of the various states in March 1959.[5]

As one reviews the research effort about technicians in general he is struck by the discrepancy between the interest and activity and the research methodology which has permitted few breakthroughs. If one has strong faith, it is not too much to assume that we may learn of the knowledge or cognition demands on the technician. Perhaps our skills and understanding in investigating the affective aspects of engineering and scientific manpower will yield data for educational planning. Our investigation of the psycho-motor aspect falls far short. A committee states the predicament thus:

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[4] George L. Brandon, Twin Cities Technicians. East Lansing: College of Education, Michigan State University, 1958.

[5] George L. Brandon, National Summary of Technical Education Research Studies and Surveys. East Lansing: Bureau of Educational Research, March 1959. (Mimeo)

> Our original plans conceived of three major parts to the complete taxonomy. The cognitive domain includes those objectives which are roughly described by the term knowledge, intellectual abilities, and intellectual skills. This is the domain which is most central to the work of achievement examiners. It is the domain in which most work in curriculum development and formulation of educational objectives in behavioral form has already taken place. . . .
>
> A second part of the taxonomy is the affective domain which includes objectives described under such terms as interests, appreciation, attitudes, values, and adjustment. We have devoted much of our meeting time to attempts at classifying objectives under this domain. It has been a difficult task which is still far from complete . . . .
>
> A third domain is the manipulative or motor skill area. Although we recognize the existence of this domain, we find so little done about it in secondary schools or colleges, that we do not believe the development of a classification of these objectives would be very useful at present.[6]

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[6]A Committee of College and University Examiners, Taxonomy of Educational Objectives. Preliminary Edition. New York: Longmans, Green and Company, 1954.

III. The Research Procedure of Project 629

It should be reiterated that this research set out to develop a study or a method by which the activities and understandings of technicians could be determined. Development, then in this sense of the term meant a dual process: (1) examining data which are presently procurable, and (2) reviewing the methods by which the data were obtained. Inasmuch as the study was developmental in nature, the following procedure was originally conceived as experimental, suggestive, and dependent upon specialist opinion.

Step 1 Collection. Collect in a centralized place the existing occupational analyses and data which are available, including occupational titles and census of industry and manufacturing. Data of this nature may be found in files of the U. S. Department of Labor, Air Force, Army, Marines, Navy, and of the Civil Service Commission in addition to those of professional organizations and industries.

Step 2 Examination and Analysis. When the materials and information are centralized and as complete as possible, assemble a working group of four to six specialists to analyze it. The bulk of these materials might feasibly demand four or

five days of examination. Persons or consultants of the following expertness are thought to be useful in this process:

a. Two or three personnel-analysis consultants who are familiar with the materials (and others in the field) and who know the nature of these data, their origin, and the methods of collecting them.

b. One (no more than two) occupational analysts who may be generally familiar with the material, but who are specialists and familiar with occupational analyses and the new trends and techniques in making them.

c. An industrial specialist, perhaps a technical and engineering personnel man, who knows the industrial structure and the current employment and utilization of engineering manpower in the various industrial classifications, that is, automotive, aeronautic, chemical industries, etc.

d. A research specialist.

This working group would thoroughly review the materials and the occupational data for their (1) basic nature, (2) activities and functions, (3) knowledge and understanding needed, (4) samples represented, (5) kinds of analyses used, (6) departments or areas (research, design, production, installation, operation, etc.), (7) military-civilian relationships, (8) criticality, and other aspects which they may suggest. The group may wish to determine if these data can be summarized, if it is adequate for an opinion, what occupations may be missing, what problems should be recognized, what additional data might be presently available and should be secured. The outcome of the action should be the formulation of a set of recommendations to the

project investigator regarding the analysis and its implications for (1) a thorough occupational analysis, if needed, and (2) next steps.

Step 3 Exploration of Project Design. Utilize analyses and recommendations of Step 2 to determine the general and specific procedures to collect data for a reliable technician study. Utilize for this purpose a consultative group of specialists comprising:

a. One or two research experts
b. An industrial psychologist
c. An industrial sociologist
d. An industrial personnel man
e. An occupational analyst
f. An educational curriculum expert

This group might in the course of four or five days broadly sketch the contour of the research design as it looks at (1) Step two's analysis, (2) needs or information which may be lacking, (3) sampling, (4) methodology, (5) nature of data needed for educational planning and curriculum development, and (6) other aspects as it may envisage them. Again, formal recommendations should accompany the research planning for the next step of implementation.

Step 4 Implementation and Detailing. The purpose of this step is to pull together the recommendations of Steps 2 and 3 and, if possible, to finalize the planning of the Project up to an experimental try-out, pilot investigation, or "dry run".

Working consultants comparable to those previously used (or recommended referrals and resource persons) will be employed here. This effort should bring in the ultimate refinement of the problem, specific questions to be answered, the methodology, plan of attack, types of analysis and treatment, a time budget, and a target report.

On the whole, there were few deviations from the above procedure as the study progressed. Step 1 (Collection) had informally commenced before the project was initiated, was maintained during the progress of the study, and is still being made as this report is written. This is not to imply that the project has collected all of the available occupational analyses and related studies. The real shortcoming of the collection step is that it has been impossible to secure analyses of technician occupations from industry. They may not exist in quantity. A determined effort has been made, however, to forward the occupational-anaysis effort; it is important to keep abreast of the investigations of occupational analysts in terms of the process or methodolgy used in making job studies and the experimentation in the field.

In connection with Step 2 (Examination and Analysis) and Step 3 (Exploration and Project Design) a great deal of formal and informal consulting with experts occurred.

Two three-day conferences were held, and the recommendations which grew out of these are reported in Section IV. Individual specialists were consulted in connection with these aspects of the procedure. It was impossible to secure specialist opinion on many aspects of the problems originally considered in the first two stages. For those who may engage in research which utilizes consultation and group opinion as in Project 629, it is recommended that the size of the group be determined in terms of the dimensions of the task. This precaution will be well taken when inquiring about the mysterious and often controversial domain of the technician.

Finally, in Step 4 (Implementation and Detailing) considerable difficulty was encountered in pulling together divergent ideas to make up a research design for future use. Doubtless many of the ideas seem to represent personal research interests of the individuals consulted, and these are difficult to reconcile with the needs or demands of constructing a research design. Another ever-present hazard in consolidating suggestions and ideas is one of communication. It is probable that some consultants to Project 629 were suggesting techniques appropriate to the time, manpower, and finances of a research center or foundation rather than to the realistic efforts and resources

of a part-time investigator. There is no doubt that the urgency and importance of the research should merit major support, but the differences between a bureau operation and that of an individual remove them from comparison.

IV. Exploring the Role and Contribution of Occupational Analysis

The interest of individuals, organizations, institutions, and agencies concerned with the utilization and preparation of industrial technicians is extremely high. The purpose of Step 2, the examination of occupational-analysis data, is especially challenging to research personnel and educational planners. Project 629 involved a small group of occupational analysts for a three-day (December 15-17, 1959) work session to specifically investigate job-analysis data for their implications to educational planning for technicians. The following research consultants met with the investigator at Kellogg Center, Michigan State University:

Leon A. Blumenthal, Occupational Specialist, Standards Division, U.S. Civil Service Commission, Washington, D. C.

Lynn A. Emerson, Special Consultant, Area Vocational Education Branch, Office of Education, U.S. Department of Health, Education, and Welfare, Washington, D. C.

Carl A. Heinz, Chief, Placement Methods Division, U.S. Employment Service, Washington, D. C.

Day Morris, Personnel Director, Continental Motors Corp. Detroit, Michigan

D. G. Price, Head, Billet and Qualifications Research Branch, Personnel Research Division, Bureau of Naval Personnel, Washington, D. C.

The group informally testified to the fact that the analysis process in the world of work has grown increasingly complex and dynamic; the role of the industrial technician and his identification have added new research needs and problems to the analyst's function in discovering work activities and supplementary information. In addition to numerous materials, research studies, and publications which had been collected by the investigator, the consultants brought many other evidences of activity analysis and study to the conference.

A. General Results of the Conference

The general problems and concerns of the consultants were similar to problems which confronted earlier meetings, conferences, and conventions about technicians and their roles. The definition and preparation are subordinate to recognition of the role of education in overall development. The consultants made a sharp distinction between training and education, they advocated that both preparatory and in-service programs recognize student needs of all factors in the industrial work environment and the development of intelligence in students at all levels.

Many levels of technician activity are recognized. It is generally assumed that the level of technician activity is characterized by the amount of technical skill (which includes the knowledge of a science or professional field) necessary to perform work functions and fulfill responsibilities. One critic states the problem thus:

> Some craftsman jobs will have a loading of "technical" content without making the job or the occupation in which it is included technical. Many "technicians" will spend a considerable part of their time in performing manipulative and repetitive tasks which can be considered as involving the application of mathematical and scientific knowledge only when the task is initially being learned. On the other hand, in terms of overt behavior and tasks performed, there will frequently be nothing to distinguish between the work of an engineering technician and that of an engineer, or between a dental technician's and a dentist's.[7]

A great deal of information is available from occupational analyses and job studies and surveys. No doubt much of this information is helpful to researchers and educational planners. On the other hand, time might be lost or dissipated in gathering analysis materials which may, in the end, be of little use. Many analysis materials may be irrelevant and

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[7] E. D. Carstater, Working Paper on Michigan State University Project 629, Developmental Technician Research. East Lansing: Bureau of Educational Research, December 14, 1959. (mimeo)

jerry-rigged to meet various local requirements and special conditions.[8]

There is very strong feeling that standards or criteria are needed to categorize technician occupations. The recognition of this need is neither new nor revolutionary.[9]

The analysts working with Project 629 are in strong accord in urging greater research cooperation among persons, agencies, institutions, and organizations. This need might be implemented by agencies on the Federal level, but there are numerous opportunities for regional and state cooperation as well. A greater concern for research should be developed on all levels; state, regional, and national conferences and conventions should feel obligation to provide clearing houses and idea exchanges. Though analysts are sincere in their

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[8] Ibid., p. 5.

[9] "The Identification of a Technical Job". Committee on Institute Curriculums, A Guide to the Development of Programs for the Institutes of Applied Arts and Sciences. Albany: University of the State of New York, 1946. (Technician Criteria score system subsequently employed in the revised interview form of G. Brandon, Twin Cities Technicians (Michigan State University, 1958) and M. Bodine, A Study of the Areas of Training Needs of Highly Skilled Technicians in Twenty-Three Selected Manufacturing and Processing Firms in Kansas (Kansas State Board for Vocational Education, 1959).

efforts to cooperate in inter-agency and organisational research problems, they are at the same time reluctant to have their interest misinterpreted as intrusion or "muscling in". There is need for administrative recognition of cooperative research effort and for attaching responsibility to designated persons.

Finally, the general interest of the occupational analysts is related to a curriculum--research product which has not come out of their job analysis: identification of functional understandings needed by technicians to achieve their maximum potential in technical occupations. Unfortunately but commonly, these understandings, under existing pressures, are stated in terms of mathematics and science learnings. Though few consultants would minimize the importance of learnings in these areas, they recognize that the values of other understandings must not be overlooked in curriculum research or educational programs. As technicians seem to work in a dynamic complex subject to constant change, there is great concern for the development of understandings and competencies associated with communications, human and supervisory relationships, occupational adjustment, and citizenship. These understandings are conceived as functional and active -- they constitute a challenge of large dimensions.

B. Consultant Suggestions and Recommendations

The consultants endeavored to operate within and make recommendations in terms of two general frames of references: (1) the nature of existing data related to this study's purpose, and (2) advisory functions in projecting their ideas to next steps in this study and a subsequent long-term project. Five specific questions confronted them to make up the first frame of reference: What is the nature of data which presently exist, and what is their potential to:

1. describe the nature of highly skilled technician work, that is, in what activities are technicians engaged and to what extent?

2. indicate the extent to which technicians use functional understandings in mathematics, science, communications, and human and supervisory relations?

3. reveal a common core or base in the educational programs of all industrial technicians?

4. disclose the vocational-guidance or occupational-adjustment information which is important to the roles of technicians?

5. indicate the presence of clusters of technical occupations which might suggest a pattern or organization of educational programs?

The tone and nature of consultant discussion related to the above questions have been described previously in this report. The following are some more specific suggestions and

recommendations which evolved as clarification was sought and made:

1. Sharply delimit the research to highly skilled technicians.

2. Use the end-products of occupational analysis and not the source data. Some of this infomation is available in the form of drafts which, if reviewed, may indicate what additional data may be necessary. In some cases it may be necessary to refer to source data.

3. Review the various classification and qualification systems of the U.S. Employment Service, Civil Service, military departments, National Science Foundation, professional groups, industrial organizations, and others in order to determine how classifications may aid in recognizing clusters of occupations and other problems.

4. "Tease out" the special implications of analysis data (particularly those of the U.S.E.S.) for their implications for technician occupations. Perhaps extract a trial or test sample from the U.S.E.S. system and adapt it to minor analysis with particular concerns for the range, scope, and depth of manipulative skills to technical skills. Check "table of equivalents" of Continental Motors Corporation and others for their possibilities.

5. Make an attempt at the definition of "technician", at least in general terms, and explore the possibilities of constructing criteria which might identify or categorize technician occupations.

6. Be alert to related problems and areas which indicate needs for research and study, and make recommendations to support this research activity.

7. Investigate the possibilities and opportunities for cooperative and contract research and liaison with other organizations:

American Association of Junior Colleges
American Vocational Association
American Society for Engineering Education (Technical Institute Division)
American Technical Education Association
National Council of Technical Schools
National University Extension Association
American Society of Training Directors
National Office Management
American Society of Personnel Management Association
Aircraft Industries Association
National Society of Tool Engineers
Electronics Industries Association (Foundation for Instrumentation Education and Research)
American Personnel and Guidance Association
Instrument Society of America
National Science Foundation

8. Explore the Skinner Process (machine teaching on an individual basis) for its implications.

9. Make a review and analysis of current curriculum efforts in the individual states regardless of their formal association with the provisions of Title VIII of the National Defense Education Act.

10. Select a group of technicians for whom little has been done in technician education (for instance, radio-isotopes technicians) and develop a research technique for curriculum study and possibly the evolvement of criteria.

11. Promote greater interest and participation in technician research among the various regions and states in cooperation with the Area Vocational Education Branch and other areas of the U.S. Office of Education.

12. Study of what is needed in the common core of educational programs for industrial technicians, and perhaps appraise offerings in human relations, industrial relations, industrial economics, communication skills, etc., as well as in basic science and mathematics.

13. Secure cooperative research between educators and scientific and technical associations. This prestige may help to gain acceptance of programs which, in whole or in part, may have been developed previously. We should not rediscover all of the ideas and programs for the sake of independent development.

14. Secure the interest, cooperation, and participation of organized labor.

15. Investigate the potential of the following human and physical resources in connection with many of the recommendations listed above.

a. Determine the interests and activities of the state employment offices.

b. Investigate the research activities of colleges and universities.

c. Become acquainted with the activities of the instrumentation technician group, and follow the study of the Task Force on Instrumentation Technicians, Instrument Society of America, Abner Hathaway, Chairman, United Electronics Laboratories, 3947 Park Drive, Louisville 16, Kentucky.

d. Review Bulletins #228 (Office of Education) and #1332 (New York State).

e. Seek National Industrial Conference Board assistance.

f. Review the U.S. Employment Service Verification Manual.

g. Consider a number of consultants for assistance. (See Appendix)

C. General Reaction of the Investigator to Discussion and Recommendations

The investigator is enthusiastic about the interest and the vigor with which all of the consultants worked on the aspect of Project 629. General discussion was frank without personal conflict, and there was concentrated effort to get everyone's ideas and to stay with problems directly related to the research. The consensus was that research can and should move forward

to clarify many problems related to preparation of technicians. Notwithstanding, the consultants agreed that severe delimitation of the research must be established, and cooperative effort should be sought wherever possible. They recognize that acting on their suggestions may require ten years of research activity. They are agreed that Project 629 should not dilute its efforts toward obtaining curriculum-planning data in order to carry on occupational analysis unless, in extreme cases, there may be no other solution or data for consideration.

A great deal of occupational information, analyses, and related publications and materials is available for study, and many interested, competent, and creative people could contribute to the clarification of the technician complex. There are funds to support the research which is needed. The consultants believe that research will ultimately offer many solutions, if planned and conducted cooperatively with a high degree of communication and involvement of interested persons and groups. Reassuring in an educational milieu where only positive solutions and answers have been aceptable, there is recognition that the research effort itself is indispensable -- notwithstanding negative and results.

V. Exploring Problems and Methods of Technician Research

A second meeting of consultants to Project 629 reviewed the suggestions of the first conference, and formulated strategy for a long-range technician study oriented toward curriculum designs which might grow out of the current project. This section of the report is an account of the inter-disciplinary approach which was a product of the second conference.

A. Personnel and Nature of the Second Research Conference

The Director of Project 629 is indebted to the following research consultants and to the organizations, agencies, and institutions which they represented or which made possible their services. The sustained interest and participation of the group during the three-day conference, February 23-25, 1960, at Kellogg Center, brought forth the substance of this section of the report and provided hints to the guidance of Project 629.

Dr. Charles A. Blackman, College of Education,
Michigan State University

Dr. Lawrence Borosage, College of Education,
Michigan State University

Mr. Dean T. Brown, Technical Education,
Chrysler Corporation

Dr. E. D. Carstater, Personnel Research Division, Department of the Navy

Dr. William A. Faunce, Sociology and Anthropology, Michigan State University

Dr. William H. Form, Sociology and Anthropology, Michigan State University

Mr. Harry I. Hadley, Personnel Management Branch, Department of the Army

Mr. Carl A. Heinz, Placement Methods Division, Department of Labor

Dr. C. B. Mendenhall, College of Education, The Ohio State University

Mr. Thomas J. Mills, Scientific Manpower, National Science Foundation

Mr. Charles E. Odell, Older and Retired Workers Department, United Auto Workers

Dr. John M. Parsey, College of Education, Michigan State University

Dr. J. D. Teller, Classification Standards Programs, Department of the Air Force

The personnel of the second conference brought a depth of experience and study from the fields of education and industrial training, psychology, sociology, and personnel research and analysis.

In keeping with the exploratory nature of the project, few attempts were made to structure the discussion; the aim was to create and sustain a climate of free ideas and creativity. The specialists had been provided with a brief description of the project, and the report of the first conference of consultants.

The two specific purposes of the conference were: (1) to review the purposes of Project 629 and determine its direction for the remainder of its formal, active period, and (2) to devise strategy for a long-term effort which would bring forth knowledge about industrial technicians and the planning of educational programs for their preparation. The extent to which these objectives were achieved is due to discussion and recommendations, suggestion of resources for further investigation, and the synthesis of ideas derived from both conferences. This section attempts to reflect the ideas, suggestions, and recommendations of the Second Conference, their relevance to the discussion of the First Conference, and any consensus of the two discussions. Specific action for the direction of the remainder of the effort of Project 629 was to be determined from the follow-up of the many suggestions.

B. General Nature of the Discussion

Conference discussion generally categorized itself into three phases or aspects of ideation. These aspects are not necessarily sharp in their delineation; they do represent several general large areas of concern about technicians and technician

research. Subjectively, it is remarkable that the discussion of consultants, evolving problems, suggestions, self-activities, irritations, illustrations, ideals, etc., should bring into focus possible solutions. Discussion may be summarized generally as follows:

1. Interest and concern for educational values in general, that is, education for change, guidance and counseling, and occupational status.

2. Interest and need for criteria, classifications, and evaluation scales to identify technician occupations; that is, to structure the problem so as to make it "researchable", and to permit isolation of specific research tasks and objectives.

3. Suggestions for pilot and long-term technician research.

The conference brought forth overwhelming evidence that there is interest in the technician complex and its implications both for the economy and for education. It noted: (1) the need and value of a basic definition of technician, (2) the need for clarification of technician occupations and employments and their location within the occupational hierarchy, (3) the need to utilize technicians on a planned, long-term basis, (4) the role of education in the preparation of technicians, and (5) the research and methodology which might deal with these problems.

C. Educational Values in Change, Selection, and Nature of Work

The Second Research Conference began with discussion of education for change. Questions were raised about the purposes of education (for technicians), the development of persons in technical occupations, the emergence and obsolescence of fields in rapidly developing technologies, the meaning of the terms "qualified" and "highly skilled", and the measurement of personality and temperament. The importance of educational guidance and selection was implied as the consultants discussed the working and status relationships of technician and engineer and the need for recognized status of the former in both economic and social contexts. It was brought out that the technician is constantly striving to reach some of the goals of the engineer, thus a parallel of progress seems to exist: there was reluctance to encourage good technicians to become poor engineers.

Special interests of persons entering technical occupations, educability, need for an analysis of required abilities, changes in job location and job content, and need

for keeping technical jobs interesting were discussed in the opening session of the conference, as well as the possibility that the pattern of the learning process for technicians may differ from that followed in the programs of engineering and scientific institutions.

Some discussion described the nature of technician work in maintenance and operation, the necessity of knowing whether maintenance and/or operation is the technician's specific task, the place of both operational and preventive maintenance, and the technician's role in training operators in operational maintenance.

It was brought out that the term "technician" is often one of fashion and prestige; there is no common, accepted definition of the word. There is a general or "model" concept; it is the boundaries that are not defined. The term is used sometimes to deprecate the functions performed by professional engineers and technologists; sometimes to enhance the status of skilled craft jobs or craftsmen.

One research consultant raised a series of questions preliminary to the conference.[10]

For whose use are the studies to be made?

What kinds of decisions need to be made that require findings of research?

What is the nature of the "research-derived" information required to facilitate decisions or make them better risks or calculated ones?

Do we have the "art" in a sufficiently developed state to provide findings useful to decision-making? If so, how do we go about selecting and sequencing the operations or techniques to suit the situation? If not, what developments in the state of the art need to be worked on?

Is there an adequate base in scientific theory and scientific-technological methods to support the needed developmental studies? If so, how should these studies be structured? If not, what "basic research" needs to be undertaken with directed priority to support the needs?

Whose interests are affected (and in what ways) by the matters under discussion here?

1. Students, parents, community organizations?

2. Trainees, employed workers, employing industries, their unions and associations?

3. School systems, secondary and higher educational institutions?

What terms do we need to define or use with agreed meanings? (How can we get the agencies whose interests are affected to use "the same language" in useful communication?)

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[10] Dr. E. D. Carstater

What are the dimensions of the field in which we are working? How is the work to be done here and now oriented with respect to these dimensions? What limitations are (1) imposed, (2) accepted / recognized? We must be careful not to overgeneralize our solutions to recognize that a solution may not be the solution -- even within the limits imposed, accepted, or recognized.

Can we suggest other approaches, plans of action, lines of study which could be undertaken by other services or organizations; or circumstances in which other approaches would be preferable -- for example, different approaches within different parts of states or different industrial complexes.

D. Criteria and Evaluation -- Critical Areas to Identify Occupations

A great deal of discussion was devoted to the critical need for standards or criteria for identifying technician occupations or technician employments, a term used by one consultant to designate the many jobs in the hierarchy not necessarily constituting an occupation or a career field. Although the conference discussed various formal groups of criteria as employed by industry, the military services, and education, most consideration was given to the classification of the U.S. Employment Service. This system was reviewed very briefly by Mr. Carl A. Heinz.

The investigator is strongly impressed by the value and need of criteria, as evidenced by the statements of various specialists who have been consulted. The greatest need seems to be for a group of criteria which would indicate a level of technician work or an identification of a technical occupation in its proper relationship with other technical occupations which demand vastly varying amounts and kinds of skill and knowledge.

E. Suggestions for Pilot and Long-Term Technician Research

Though recommendations for an extension of a long-range technician research program were few, the conferees had many ideas and suggestions for this study. Some of them follow.

1. The need to assemble basic information from existing sources.

2. Necessity for delimitation.

3. The need to define a requirement for the development of a system, which may be directed to an office or center for a technical developmental program.

4. A definition of tasks to be performed if a long-range objective is to be observed.

5. The designing of research without an actual pilot run.

6. Concentrate the research by industry; take two or three of the best of each industry.

7. Confine the research to an individual community (community to be considered as beyond the limits of a school district) or a series of communities, not a national effort.

8. Sample from industrial complexes rather than communities.

9. Do not rely upon a review of all current curricula of existing schools and programs.

10. Gather together information, and concentrate on a small, one-community project. Determine duties and functions, and pilot-test these in other communities.

11. Explore the possibilities of a common community curriculum.

12. Secure an operational definition of the concept "technician" by working from industry to industry.

13. Determine what needs to be done instead of what may be asked for (actual needs vs. stated needs).

14. To develop a training program, determine the positions (job analysis approach) and construct curriculums for training persons in these positions.

15. Set up regional programs in order to develop an interplay between educational institutions and industry.

16. Review and evaluate the various systems of job analysis and their data, and determine degree of applicability to curriculum research for preparation of technicians; for in-service development of technicians.

17. Use the present state of the art as a base from which methodological developments would improve or contribute to a new state of the art.

18. Make a regional, detailed account of problems by means of the interview technique. Narrow the scope of the project by focusing on a particular area or region. Make a sampling of community complexes (including industrial complexes) or a sampling of educational curricula.

19. Use three or four technical specialists and a coordinator to construct a needed curriculum.

20. Ascertain the core or cluster of common traits on which a curriculum may be based.

21. Identify the areas of technicians from the current USES classification, and make a rough plan of criteria from worker functions and work fields.

Various members of the conference recommended more detailed and thorough studies:

1. An Interim Study [11]

a. Begin with a small community project.

b. Sample the technician universe.

c. Decide upon job functions and tasks of technicians.

d. Tease out functional understandings.

e. Pilot-test the design in a different community.

f. Train teams for sampling other communities.

g. Draw together the various studies and extract communalities.

h. Make generalizations.

2. A System Study [12]

a. Long-Range Objective. To develop a system of educational programs for workers whose intentions or aspirations and capabilities for occupational career development do not set performance of scientific, professional, technological, or engineering tasks as

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[11] Dr. J. D. Teller

[12] Dr. E. D. Caretater

their goals, but whose talent and potential can be best utilized in employments designated as "technical", for which there is expanding need in the national economy.

(1) To provide a more adequate supply of "technically trained" manpower to perform "sub-professional" tasks so as to permit continued expansion and exploitation of scientific and technological developments by others.

(2) To provide opportunity (and incentive) for full development of the economic and cultural potential of individuals, including progressive growth and development in economic productivity: continuous adaptation and transition to changing requirements of the technical character of employment (emergent and obsolescent functions) and shifts in the organization and utilization of the work force in various fields (ratios of professionals, technologists, engineers, technicians, skilled craftsmen, operators, apprentices and helpers, casual laborers); and early achievement of employable levels of competence in jobs and tasks which provide further learning opportunity and challenge rather than repetitive routine "applications" of already developed abilities.

b. Requirement. To develop systems (programs) of career development (including in-service, part-time, cooperative, and preparatory education and training) which will effectively facilitate learning and growth in abilities that are significant to fulfilling present and foreseeable occupational demands and to participation in the affairs of a free economy and culture. The design of such systems must take into consideration:

(1) The concept of "technical employments" or jobs that are technical in the nature of the functions performed by the worker, in what may be variable relationship to "other-than-technical" functions in different work fields, industries, or services.

(2) The characteristics or "traits" which distinguish satisfactory "technicians" (and potential technicians) from other kinds or levels of workers either (a) in general, or (b) in particular occupational fields.

(3) Methods and materials of instruction and sequences of instructional goals and experiences calculated to facilitate optimally effective development at a rate consistent with acceptable levels of mastery, phase by phase (phase mastery in terms of acceptable proficiency in useful tasks and not mere "book learning").

(4) Availability of suitable instructional and supervisory personnel and adaptation of instructional procedures (methods and materials) to effective learner-teacher interaction.

(5) Availability of appropriate learning environments at successive phases of development. This provision includes employment in trainee or intern status as well as in formal school situations, and may involve at some phases the whole complex of part-time employment, part-time extension courses, related and general education, and facilities for residence, subsistence, etc. It may be necessary to consider this phasing in reverse, that is, the kinds of experiences, orientation, indoctrination, etc., which should precede an anticipated assignment to a work phase.

c. Technical Difficulties.

(1) Description of positions or classes of positions which will permit evaluation or determination as to whether the employment is technical.

(2) Criteria, evaluation standards, procedures, techniques for measuring amount, or degree of significance, of technical content in a job.

(3) Determination of dimensions and degree of communality or homogeneity needed in order to consider several classes as an occupational entity or career field.

(4) Provisions to be made for subclasses of employments and functions (non-common elements) in a career field.

(5) Alignment of job requirements, job-oriented qualifications, "man-package" qualifications, best suited aptitude profiles, threshold qualifications for entry employments, that is, "acceptable risk" characteristics for acceptance as trainees.

(6) Adaptation of instructional processes (a) to characteristics of trainees as learners, that is, actual typical input (not that which someone thinks students ought to have), and (b) training objectives derived from analysis of work content and qualification requirements.

(7) Development of methods and techniques of learning for transfer.

(8) Development of guided-discovery techniques for learning laws, principles, generalization, relationships, and for extending their application in new situations and technical contexts.

(9) Facilitation of the school-job and job-school transition; from learning in school to learning on the job; continuous summation and integration of learning and competence.

(10) Application of reinforcement principle in practical situations.

d. Technical Resources. Available methods, techniques, procedures, models, etc., for meeting technical difficulties: (1) current state of the art, (2) applications of new and recent research findings.

e. Implications for Research.

(1) Development and evaluation of experimental techniques, methods, processes, aids, materials.

(2) Research in basic areas: learning, developmental psychology, psycho-dynamics.

f. Sub-Projects and Tasks.

(1) Feasibility study. Can the requirement be met? With what expenditure of effort and cost? Length of time involved, requiring the involvement and cooperation of what agencies in making their resources available or in performing planned work?

(2) Sub-systems. Scientific and professional aids, research and development. Technicians in: (a) research and development (scientific and professional aids); (b) medical and healing arts, public health, safety; (c) engineering and physical science technologies; (d) communications; (e) industry and production; (f) management, administration, fiscal funtions; (g) service occupations.

(3) Operational criteria and evaluation procedures for identifying technicians' jobs.

(4) Identification of entry level of technicians' jobs.

(5) Study of emergent functions of techniciane.
(a) Specialization and routinization of engineering and technological tasks; (b) quantification and application of scientific procedures and processes to functions performed by artisans and craftsmen; (c) reorganization of the work-force "mix" through mechanization and automation of processes.

F. A Synthesis of the Two Research Conferences

The investigator did not try to direct the discussion of the Second Conference to the ideas of the consultants who participated in the First Conference. Reports of the December meeting had been sent to those persons who participated in February. Additional liaison was provided through Mr. Carl A. Heinz, a participant in both conferences.

There were numerous general similarities of the ideas of the two groups: (1) the importance of the project and the interest it generated, (2) the increasing complexity of occupational analysis and evaluation, (3) the concern for definition, (4) the interest in guidance, selection, and educability, (5) the recognition of the problem of giving status to technician occupations, (6) the need of standards, criteria, and evaluation, and (7) the importance of overall problem or "system" study.

The following tabular digest of specific ideas, suggestions, and problems provides comparison of the two conferences.

Suggestions of Group I Conference of Analysts	Reactions of Group II Interdisciplinary Conference
1. Delimit study to highly skilled technicians.	1. Broaden study to include other categories. Set the study in broader context or perspective.
2. Use <u>end-products</u> of occupational analysis, not source data.	2. Some minor agreement, some disagreement. No consensus. (a) Try to use the "end-products", (b) go back to source data to try to remedy deficiencies resulting from its processing. (c)Determine what needed data were omitted when analyses were made in the field (data-gathering stage).
3. Review classification systems.	3. Strong agreement.
4. "Tease out" special implications of analysis data (particularly USES).	4. Recognized, but no strong recommendation.
5. Attempt to define "technician", at least in general terms.	5. Recognized value; more concern with general criteria and evaluation. May require multiple or differential definition in different areas.
6. Observe related problems which need research, and support the research activity.	6. Fully in accord and possibly include in system study.
7. Investigate research interest and support on many other organizations.	7. Need to enter cooperative planning and coordination of effort if long-range objective is to be served.

8. Review and analyze current curriculum efforts.	8. Little support for this. (a) Current curriculums -- utterly useless as research effort; (b) methods of curriculum study and development -- possibly useful but requires careful and critical evaluation as to relevance to present problem.
9. Develop a research technique from experimentation with a specific group of technicians, for example, radio isotope technicians.	9. Broadened to include a community, or an industrial complex on a small, modest scale.
10. Promote greater interest and participation in technician research.	10. (a) Within educational circles, there seems to be sufficient interest, but also some fear of the enormity of the problem. Hence the need for a long-range coordinated plan to "promote participation". (b) On the local level, need for development of cooperative involvement of groups whose interests are affected was discussed in connection with lack of replication of the Twin Cities Technician Study.
11. Investigate the potential interest and support of suggested resources.	11. No consideration of this, but a few other activities and resources were suggested.

VI. The Resolution of a Research Design

The central problem of Project 629, to determine or to develop a method by which the needed understandings of technicians may be found, is not peculiar to this research. This same problem plagues the occupational-analysis efforts of many groups under the term "qualifications analysis", and it is concerned with both the technician as a person and his job. Its current status, at least in the military aspect of government, is reported in a recent research symposium.[13]

After consideration of the suggestions and recommendations which are reported previously, Project 629 adopted as a tentative model a matrix or nomograph which was originally projected to the investigator by Dr. Raymond Christal and Dr. John Krumboltz after considerable study.[14] An outline of the problems and procedures is presented here.

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[13] Office of Naval Research, Tri Service Conference on Job Qualifications Analysis, ONR Symposium Report ACR-41. Washington: Department of the Navy, May 1959.

[14] Gerald L. Hershey, Project 629 -- Developmental Technician Research, Report of a Research Proposal, East Lansing: Bureau of Educational Research, Michigan State University, April, 1960 (Mimeo).

A Matrix Model

		Technician Job Titles			
	Examples	**Title 1**	**Title 2**	**Title 3**	**Title 4**
Concepts:	**Functions of a right triangle**	0	1	2	3
Skills:	**Oral communications**	1	2	3	3
Courses:	**Physics**	0	0	1	0
Aptitudes:	**Manual dexterity**	0	1	1	1

(Rating key: 0, none required; 1, little required; 2, average required; 3, great required)

A. Outline of Matrix Model

1. Defining the job and developing means to identify incumbents in the jobs (horizontal element in final matrix).

2. Obtaining detailed descriptions of current and future job activities.

3. Inferring needed concepts and skills from job activity descriptions (vertical element in final matrix).

4. Selection and training of raters.

5. Development of matrix with values in each cell (vertical: concepts, skills and/or courses -- horizontal: specific technician's jobs).

6. Analysis of data in the matrix.

B. Discussion of Outline

1. Defining job and identifying incumbents.

a. Dictionary of Occupational Titles (DOT). Since the Department of Labor, DOT, is in use all over the country, simply adopt its titles and descriptions in order to locate technicians. If necessary, combine two or more DOT titles in order to match actual incumbents on the job. This may solve our problem of definition.

b. Use latest Department of Labor data on research and development of technicians. Since this group of technicians is in demand today, since a more detailed job description is available, and since descriptions do match actual jobs, this might act as a starting list.

c. Sampling problem. Whether to select group of technicians from one segment of industry (steel, chemical, automobile, etc.) at a time or to sample similar types of technicians regardless of industry (research and development technicians, maintenance, etc.). There is danger in making the job categories too broad (breaking into clusters, aircraft, steel chemical, etc.).

d. Develop a scale to classify technicians. Possibility of the development of a scale to determine the level of technicians' skill (high to low), then decide to be concerned with technicians only at a certain skill level.

e. Use existing technician job titles in industry. Arbitrarily select certain jobs with the title "Technician". Danger in lack of standardization of job titles within and between industrial clusters.

f. Note on future needs of technicians. Attempt to determine which types of technicians are and will be in demand vs. those decreasing. Also, analyze functions of engineers and scientists (and persons with degrees whom technicians serve) for ideas of technician activities of the future.

2. Obtaining detailed descriptions of current and future job activities.

a. Obtain from small sample of one type of technician (using one or more of the following: interview, observation, study of job description, and interview with immediate supervisor) the following information: percentage of time spent on each activity (mental and physical); relative importance of each activity (mental and physical); background of each incumbent; aptitudes necessary for job; interests necessary for job; personality factors; future requirements of the job (talking with research and developmental people); "entry level" and "accomplished level" tasks actually performed (amount of time spent on each).

b. Develop inventory on basis of above information.

c. Administer to large sample of these specific technicians in same and/or related industries.

d. Analyze inventory and use as basis for development of job description for raters.

3. Inferring needed concepts and skills from job activity descriptions (vertical element of matrix).

a. Determine what to include in vertical column: pure course listing (algebra, calculus, physics, etc.); textbook listing (table of contents, units); applied course listing, specific tasks; aptitude, interest, and personality determinant found to be important for the particular jobs; opinions of curriculum specialists in engineering, mathematics, natural sciences, social sciences, etc.; opinions of specialists in government, military, labor, and industry; opinions of training directors and supervisors; opinions of technicians. All opinions sought should include present and future skill or concept requirements.

b. Develop a list of several hundred (if necessary) items to include in vertical column. Number will be a function of which method(s) is (are) used under section (a) above. That is, if the course method is selected, one might use either one or both the following breakdowns in the vertical column: courses only (algebra, advanced algebra, calculus, physics I, chemistry I); courses plus particular aspects of each course (algebra, function of a right triangle, proportions, solving equation for three unknowns).

4. Selection and training of raters.

a. Criteria for selection of experts from: education (curriculum development, special engineering, mathematics, social sciences; industry (engineering, science, supervisors)--technicians may clarify job descriptions; labor (job analysis and description); government (Department of Labor occupational analysis); military (test construction, course development, evaluation, personnel research).

b. Training of experts. (1) Rating methods: Subjective -- each expert rates each item for each job (0, not necessary; 5, essential). Objective-- develop weighting scale based on Step two in terms of various tasks; for example, a formula which takes into account the importance of a task and the amount of time spent on the particular technician job but only takes 5 minutes a day or week to perform,

it would receive a different weight from a task which is of no consequence to the successful performance of the job but required 4 hours a day or week to perform. In addition, special weights could be given for "entry level" tasks that may require a great deal of time on the job for the first few weeks or months, but after a period of training may only require a small amount of time. "Accomplished level" tasks that may remain relatively stable in terms of amount of time required to perform may be also considered for special weights. (2) Rating scale. The actual scale may run from 1 to 5 (1--not necessary; 5--essential). It is suggested that a special number (6, 10, etc.) be devised for an item (task) that is critical in the particular technician job. (3) Problems. Make sure raters are rating on same criteria (the work crucial or essential may have different meaning for different raters). Check inter-rater reliability and agreement. Have them rate independently. Analyze each rater's overall ratings to determine if biases, in fact, did enter (specialist in mathematics may consistently rank mathematics subjects and principles as essential for all technicians jobs). Cross-validation of ratings (use another group of raters picked on the same criteria and have them rate the jobs in the matrix). Determine from research findings the most effective number of raters to include.

5. Development of the matrix. From the above steps, we have developed a matrix filled with ratings in terms of the importance of certain concepts, skills, tasks, aptitudes, etc. to particular technician positions.

a. Advantages of the matrix model: Values can be added to either the horizontal axis (as new technician jobs develop) or the vertical axis (as new knowledge is obtained about concepts, skills, aptitudes, etc. of jobs). Data can be analyzed on a high-speed computer. Data can be analyzed many different ways (see analysis of the matrix below). The model allows for several pilot studies to determine better methods of: analyzing tasks required of a job; developing criteria for selection of raters, criteria for organizing vertical axis of matrix, criteria for organizing horizontal axis of matrix; determining future tasks of technicians, etc. Taken into account are not only tasks of technicians, but also aptitudes, interests,

personality factors, and human relations skills found related to success of a particular type of technician.

b. Disadvantages of the matrix model: Tasks may change so rapidly that information may be outdated before analysis of matrix is completed. Necessity to do studies in areas where no present information may be available (how to best organize the horizontal and vertical axes; criteria for selecting raters). A great deal of time is involved in rating a matrix that may have several hundred columns and rows.

6. Analysis of the matrix. Generally, the following types of analyses (and perhaps others) will be facilitated by the use of a single scale which indicates the entry's relevance and importance. If such a uni-dimensional scale is not devisable, then the relative contribution of an area of importance to a job will have to be provided through the weighting given the ratings of that area, or through the extent to which the area is differentiated in relation to other areas. These solutions would permit the development of ratings or scores for each matrix entry which could be analyzed as follows:

a. By analysis of the means of the rows, determine which items on the vertical axis are essential or not essential for technicians in general or specific groups of technicians.

b. By intercorrelating the matrix, find the relationship of the various tasks, aptitudes, etc. to particular technician jobs and categories.

c. Clues may be obtained for developing or adding to the present curriculum by finding out that certain tasks, concepts, etc. are important in certain technician jobs that at present are not included.

d. In a correlation matrix one may find certain jobs falling into clusters in terms of tasks, thus leading to the development of a curriculum to train a person to qualify for several types of technician jobs.

e. By the discriminate function method.

f. By factor analysis.

g. By cluster and pattern analysis.

h. Through various types of analysis, we may find that anyone wanting to become a technician must have particular training, certain aptitudes, interests, and personality factors, in order to be successful. The tremendous implications for curriculum development and counseling and guidance in the above types of analysis are obvious.

(NOTE: An alternate proposal eliminates Steps 2, 3, and 4. Instead of getting detailed job descriptions, selecting raters, and having them infer needed concepts, skills, etc. from these job descriptions, we put the matrix before practicing technicians and ask them to rate their particular job in terms of the items on the vertical axis. This involves problems of training technicians in rating and comprehending the criteria to be rated.)

VII. Some Conclusions and An Overview

Many conclusions can be drawn from the limited research activity of Project 629. Usefulness of the matrix model presented in Section VI is limited. Application of the statistical treatment and sophisticated research method of the matrix may be open to question. Notwithstanding, the matrix method appears to hold more promise than any other which this project has explained. Its critics may be hard put to suggest alternatives. What has been learned from Project 629's extensive consultation with occupational research personnel is that, until we discover or ultimately achieve research sophistication, we are compelled to make extensive use of inference. At this time it seems that inference is utilized by most of the research which succeeds in drawing out technician needs and their reflection in curriculum planning.

The greatest need is for a system to classify technical workers from craftsman to professional. This means that criteria are vitally needed to identify the various occupations and the amount or kind of technical "skill" peculiar to them. Granted that a classification would assist us greatly in the preparation of technicians, it is improbable that any classification system would be enthusiastically received or

implemented by industrial management or labor.

The consultancy effort of Project 629 has something to say about the use of research specialists. It is believed that many more positive ideas would have been secured if more specialists had been consulted individually, or in groups of two or three. The process of recording their ideas might have been simplified. Undoubtedly, some of the broader implications of the problems, the cross-fertilization of ideas, and the inter-disciplinary relations which are very important would be sacrificed in the small -group process.

With caution, more effort might be wisely expended in securing and analyzing a large sampling of occupational descriptions analyses, and other materials from industry at large. Project 629 was not productive in this aspect of technician research.

Education (particularly vocation-technical education) should be consistently close to and well-informed of the research in personnel and education within divisions and branches of the Federal Government. Both formal and informal groups and organizations are performing research and disseminating their findings. Persons in technical education and educational research should be designated for liaison to keep abreast of activities, developments, and feedback.

Progress in guidance, counseling, and selection as related to the technician is imperative. The importance and magnitude of problems in this area are sufficient to merit a major research effort. In the area of testing alone, there are innumerable activities and research which technical education should be cognizant of. Some of these have been introduced to this project, but no follow-up has been made.[15]

In conclusion, if a sizable contribution to knowledge about technicians is to be made, a major, organized effort must be expended. Consultants to this project strongly recommend that resources of many kinds be consolidated to support a bureau or center for the study of technical education. There is immediate and long-range justification for mobilization to study technicians; they are a vital part of the "new majority"--the new, highly educated, white-collar, "salaried middle class"

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[15] J. J. LaGaipa, The Development and Validation of the Advanced Technician's Test. Technical Bulletin 59-15. Washington: Bureau of Naval Personnel, U.S. Naval Personnel Research Field Activity, July 1959. Also, J. E. Morsh and F. R. Ratliff, Occupational Classification in Some Major Government Agencies. WADC-TN-59-37, ASTIA Document NO. AD 212-540 Washington: Office of Technical Services, U. S. Department of Commerce, March 1959. (See E. S. Primhoff, J-coefficient Technique, pp. 52-54.)

of professional, technical, and managerial manpower.

Peter Drucker shows the characterization of the new majority:[16]

> In the past the question has always been: How many educated people can a society afford? Today it is increasingly: How many people who are not highly schooled can a society afford? For anyone, we are now beginning to realize, who is not educated to the limit of his abilities (and some of us -- I belong to them -- would greatly prefer to say: who is not educated quite a bit beyond the limit of his abilities) is a social weakness and a productive loss. The knowledge which the educated person brings to work, is also a very different resource fr[illegible] either "labor" or "capital". It demands different jobs, different ways of organizing the work, different opportunities, and different rewards. This is true not just for those who hold, or will hold, jobs in management or research or who work in a profession. It is true for the great majority -- for they all increasingly have the background and expectations of the highly schooled person.

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[16] In: Edgar A. Schuler, Thomas F. Hoult, Duane L. Gibson, Maude L. Fiero, and Wilbur B. Brookover, Readings in Sociology. New York: Thomas Y. Crowell Company, 1960, p. 314.

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APPENDIX

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Index to Project 629 Publications

Subject	Number	Date
The Development of a Research Design to Investigate the Functional Understandings of Technicians as Bases for Curriculum Planning in Technical Education	R1m	March 4, 1959
Exploring the Role and Contribution of Occupational Analysis	R2m	December 23, 1959
Problems, Purposes and Methodology of Research Strategy	R3m	March 31, 1960
Problems, Purposes and Methodology of Research Strategy (Revised)	R3m (Rev.)	March 31, 1960
Report of a Research Proposal	R4m	April 7, 1960
Preamble to Technician Research--A Working Paper	R5m	June 29, 1960
What Is An Industrial Technician	R6m	Jnne 29, 1960
Final Report	R7m	July 30, 1960
Abstract of Final Report	R8m	July 30, 1960
Index to Project 629 Publications	R9m	July 15, 1960
Directory of Research Consultants to Project 629	R10m	July 30, 1960

Research Consultants, Project 629

Lew Abolin, U. S. Department of Labor, Occupational Analysis Section

Charles A. Blackman, College of Education, Michigan State University

Leon A. Blumenthal, U. S. Civil Service Commission, Standards Division

Lawrence Borosage, College of Education, Michigan State University

W. B. Brookover, College of Education, Michigan State University

Dean T. Brown, Chrysler Corporation, Technical Education

E. D. Carstater, Bureau of Naval Personnel, Personnel Research Division, Washington, D. C.

Raymond E. Christal, U. S. Air Force, Wright Air Development Division

Lynn A. Emerson, U. S. Office of Education

William A. Faunce, Department of Sociology and Anthropology, Michigan State University

William H. Form, Department of Sociology and Anthropology, Michigan State University

Harry I. Hadley, Personnel Management Bureau, Office of the Adjutant General, Washington, D. C.

Carl A. Heinz, U. S. Department of Labor, Bureau of Employment Security

Gerald L. Hershey, Bureau of Educational Research, Michigan State University

John U. Jeffries, College of Engineering, Michigan State University

David R. Krathwohl, Bureau of Educational Research, Michigan State University

John D. Krumboltz, College of Education, Michigan State University

Angelo A. Lacognata, Bureau of Educational Research, Michigan State University

C. B. Mendenhall, College of Education, The Ohio State University

Thomas J. Mills, National Science Foundation, Washington, D. C.

Day Morris, Continental Motors Corporation

Charles E. Odell, United Auto Workers

John M. Parsey, College of Education, Michigan State University

John J. Paterson, Bureau of Educational Research, Michigan State University

D. G. Price, Personnel Research Division, Bureau of Naval Personnel, Washington, D. C.

J. D. Teller, U. S. Air Force

Roy Zelch, Chrysler Corporation

The following is a list of people who might be asked to function as consultants, as suggested on page 34.

Thomas Mills, National Science Foundation

Professor Riegal, University of Michigan

James Teller, U.S. Air Force

I. Hadley, Colonel, U.S. Army

Gus Lee, Director Manpower Utilization, Department of Defense

J. Cayce Morrison, State Department of Education, New York (retired)

E. D. Carstater, U.S. Navy

Howard Johnson, U.S. Navy

Leon Lewis, Division of Placement Methods, U.S. Employment Service

Thor N. Trolsen, Technician Recruiting, General Electric Company

H. C. Anderson, The Johns Hopkins University

Robert F. Kramer, Fairchild Aircraft Division

A. George Verberroth, Jr., The Martin Company

Earl Jones, Personnel Research Field Activity, San Diego, California (U.S. Navy)

Humrro, Human Relations Research Organization, George Washington University, U.S. Navy

Sidney Fine, U. S. Employment Service

Mr. Savage, Utah State Employment Service

Richard S. Nelson, Special Supervisor of Technical Education, State Department of Education, Sacramento, California

Ray Hollebach, Director Personnel Research, Parke-Davis, Detroit, Michigan

Rex Ramsey, Manager, Management Development Employee Education, Burroughs Corporation, Detroit, Michigan

Leo Smith, Rochester Institute of Technology, Rochester, New York

Ernest McCormick, Purdue University, Lafayette, Indiana

Al Chulupsky (with Earl Jones), Russell May

Ernest S. Primhoff, U. S. Civil Service Commission (test development and occupational research)

J. F. Downey Smith, Vice-President for Research, Carey Corporation, Syracuse, New York

Jeanne Miller, Editor, Technical Education News, McGraw-Hill Publishing Company, New York

James Briarley, Auto Research Planning Chrysler Corporation, Detroit, Michigan

W. J. McCortney, Director, Automotive Research, General Tire and Rubber Company, Detroit, Michigan

William J. E. Crissy, Department of Marketing and Transportation Administration, Michigan State University

Project 629 -- Developmental Technician Research

Abstract of Final Report

Introduction to the Research

The basic aim of the original proposal was the development of a research design, plan, or strategy which might adequately sample the universe of the industrial technician, particularly the highly skilled technician, and accurately discover and determine his work functions and needed understandings to perform them. As a study of one year's duration, it had no formal commitment to any particular kind of approach and no stand on the many issues of industrial organization and management.

Objectives and Significance

With the combined resources of the College of Education, Michigan State University, and the Cooperative Research Program of the Office of Education, U. S. Department of Health, Education, and Welfare, this exploratory research project attempted to facilitate realistic educational planning and curriculum construction for the education of industrial technicians. The primary intent was to provide the knowledge necessary to the development of technical education programs on the secondary and junior-community-college levels.

The specific purpose of the study was the development of a research design which subsequently could be used to investigate the work functions and understandings of industrial technicians. As primarily a study of exploration and development, the purposes of Project 629 were to: (1) obtain descriptions of the activities of highly skilled technicians; (2) determine if there exists a common core in the educational programs of industrial technicians; (3) ascertain whether the presence of clusters or families of technical occupations suggests a patterning of educational programs; (4) compile existing information on occupational adjustment which is relevant to technician roles; (5) determine the extent to which technicians use scientific principles, both physical and social, in their occupations.

Procedure

The following general procedure was set up and later revised according to suggestions and recommendations of participating consultants:

Phase I. Collection of existing occupational analyses, data, and related publications.

Phase II. Examination and analysis of the data by experts with specialized competencies in personnel analysis, occupational analysis, and research.

Phase III. Utilization of the analyses and recommendations emerging from Phase II in an effort to make a strategic research design for a pilot "dry run" and long-term project.

Phase IV. A pilot test.

Phases I, II, and III were accomplished. Phase IV awaits resumption of the research effort herein described.

The procedure stressed consultation with outstanding persons in the many agencies, organizations, and institutions interested in the preparation and utilization of technical manpower. It was planned that this be done, wherever possible, with an inter-disciplinary approach.

Some of the Major Findings

The project yielded many evidences none of which might be appropriately termed "data" in the acceptable sense of the word. The collection aspect continued throughout the project's duration; it yielded (l) numerous occupational analyses, particularly those from the various military departments of government and the Department of Labor; (2) occupational classification systems; (3) representative research reports and reviews of studies in personnel analysis; (4) community, regional, and statewide surveys of technical manpower and the need for education; (5) information about research projects

planned or in progress in governmental agencies and offices; and (6) miscellaneous publications related to the research.

Two formal conferences related to Phases I and II were held. A resumé of the discussion, suggestions, and reactions of the specialists who participated in the conferences is contained in the following two pages of this abstract. It is suggested that people interested in the recommendations obtain copies of the final report, or request conference reports R2m or R3m, from the Index to Project 629 Publications which appears in this abstract. In addition to the consultation and discussion which occurred in the research conferences, many experts were contacted individually. A few of the consultants submitted their ideas and plans in writing; many contributed publications and reports. Project 629 is indebted to all of them.

A Composite of Consultant Suggesions and Reactions

Suggestions of the First Research Conference	Reactions and Additional Suggestions Second Research Conference
1. Delimit study to highly skilled technicians.	1. Broaden study to include other categories. Set the study in broader context or perspective.
2. Use end-products of occupational analysis, not source data.	2. Some minor agreement. No consensus. Also, some disagreement. (a) Try to use the "end-products", (b) go back to source data to try to remedy deficiencies resulting from its processing. (c) Determine what needed data were omitted when analyses were made in the field (data-gathering stage).
3. Review classification systems.	3. Strong agreement.
4. "Tease out" special implications of analysis data (particularly USES).	4. Recognized, but no strong recommendation.
5. Attempt to define "technician", at least in general terms.	5. Recognized value; more concern with general criteria and evaluation. May require multiple or differential definition in different areas.
6. Perceive related problems which need research, and support the research activity.	6. Fully in accord and possibly include in system study.
7. Investigate research interest and support of many other organizations.	7. Need to enter cooperative planning and coordination of effort if long-range objective is to be served.

Suggestions of the First Research Conference (Continued)	Reactions and Additional Suggestions Second Research Conference (Continued)
8. Review and analyze current curriculum efforts.	8. Little support for this. (a) Current curriculums -- utterly useless as research effort; (b) methods of curriculum study and development -- possibly useful but requires careful and critical evaluation as to relevance to present problem.
9. Develop a research technique from experimentation with a specific group of techniciana, for example, radio-isotope technicians.	9. Broadened to include a commuity, or an industrial complex on a small, modest scale.
10. Promote greater interest and participation in technician research.	10. (a) As to interest, within educational circles, there seems to be sufficient, but also some frustration at the enormity of the problem. Hence the need for a long-range, coordinated plan to "promote participation". (b) On the local level, need for development of cooperative involvement of groups whose interests are affected was discussed in connection with lack of replication of the Twin Cities Technician study.
11. Investigate the potential interest and support of suggested resources.	11. No consideration of this, but a few other activities and resources were suggested.

Resumé

The project ultimately led to the construction of a matrix model as a design for technician research. The matrix is built around a vertical axis of elements (concepts, skills, and/or courses) and a horizontal axis of specific technician occupations. The matrix could be broadly constructed to represent many technician occupations, and a multitude of vertical elements of course content, course listings, concepts, job activities, etc. might be included; the matrix could, on the other hand, be quite narrow in limiting the number of technician occupations to a few in a given cluster or family, and a restricted number of elements on the vertical axis. Whatever its ultimate scope, a group of "raters" would be employed to determine the value of the various elements in the vertical column.

Generally, the analysis of the matrix will be facilitated by the use of a single scale which indicates the entry's (a) relevance, and (b) importance. If such a uni-dimensional scale cannot be devised, then the relative contribution of an area of importance to a job will have to be provided through the weighting given the ratings of that area, or through the extent to which the area is differentiated in relation to other areas. These solutions would permit the development of ratings or scores for each matrix entry, which could be analyzed

in various ways.

Advantages of the matrix are: elements can be added to either axis, data can be analyzed in many ways, pilot studies can be made, and possibly aptitudes, interests, personality factors, and human relations skills can be investigated. Disadvantages are also encountered: tasks and activities of technicians may change too rapidly to be evaluated, a great deal of time may be consumed in rating a matrix of a great number of columns or rows, and it may be necessary to make studies in areas in which no present information is available, for example, the organization of the matrix, and the criteria for the selection of "raters".

Conclusions

In terms of problems involved in discovering knowledge to facilitate planning of technician education programs, it is generally believed by consultants that an "all out" effort should be made to promote education research about technicians. This fact essentially requires that a center for the study of technical education be established, and numerous resources, financial and institutional, support it.

The matrix concept has considerable merit, but it also has limitations in its research sophistication. Perhaps

too much stress is placed on inference and the employment of raters in making judgments of value of the various elements. On the other hand, and despite these serious shortcomings, it is highly probable that critics of the matrix will have few, if any, positive alternatives to propose at this stage of our research.

By far the greatest need is for a classification system, a group of criteria, to identify technical workers from craftsman to professional. Granted that a classification would assist us greatly in the utilization of technical manpower and might assist education in the preparation of technicians, it is highly improbable that any classification system would be enthusiastically received or implemented by either industrial management or labor.